THE EFFECTS OF WILDFIRE ON ARTHROPOD POPULATIONS IN JARRAH-*BANKSIA* WOODLAND

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ABSTRACT

This study investigates the response of arthropods to fire within the fortnight immediately following burning. Arthropods were sampled in pitfall traps and by hand-searching in potential refuges in both burnt and unburnt areas. There were more individuals representing more species in pitfall traps from the burnt area, suggesting that many former foliage-inhabiting species survived and were restricted to ground level. The natural histories of some of these species supported this view and several species found in unburnt *Banksia* canopies were also sampled in pitfall traps in the burnt area. The dense crowns of *Macrozamia riedlei* and *Xanthorrhoea preissii* provided refuges after fire for several arthropod species not usually found there. The ability of arthropods to survive predation and starvation until vegetation regeneration occurs is discussed.

INTRODUCTION

Natural bushfires have occurred in Western Australian dry sclerophyll forests and woodlands for a very long time, perhaps since the late Tertiary (Main, 1976). Many plants of these ecosystems possess adaptations which enable them to withstand fire and it is clear that periodical bushfires do not constitute major disturbances in fire-prone plant communities (Whelan, 1977; Whelan and Main, in prep.). There are some studies on mammals which show that some species can tolerate fire (Newsome *et al.*, 1975; Christensen, 1978; Main, 1978) but the data on invertebrates are scarce (Bornemissza, 1969; Springett, 1976) and mainly restricted to anecdotal observations.

Whelan and Main (in prep.) showed that fire caused a sufficient reduction in populations of acridid grasshoppers to allow increased survivorship of seedlings of some plant species and the protection from grazing was more pronounced in a clean burn of large area than in small burnt patches. Arthropods are likely to be able to use small unburnt refuges in even a hot, clean fire and from them reinvade burnt vegetation as it regenerates. For example Bornemissza (1969) recorded a recovery of insect fauna on shrubs and herbs within one year of burning.

In view of the lack of documentation described above, this study is a comparative and quantitative analysis of arthropods found on the ground after fire. The abundance of the ground fauna has been measured in both burnt and unburnt Jarrah *(Eucalyptus marginata)-Banksia* woodland vegetation and the species composition of fauna which use the plant species as refuges has been analysed.

STUDY AREA

This work was undertaken at the University of Western Australia's Marsupial Breeding Station near Jandakot, about 25 km south of Perth. The vegetation is typical of the Jarrah-*Banksia* association of the Bassendean sands with scattered swampy areas dominated by paperbark *(Melaleuca preissiana)* and *Banksia littoralis* (see Seddon, 1972). On 14 March 1977 a wildfire burned out about 100 hectares of the 290 ha research station, destroying almost all the ground vegetation and many tree canopies. Some small patches of unburnt vegetation (up to 10 m^2) were left where there was insufficient ground litter to carry the fire. This study was started on 16 March, the second day after the fire.

METHODS

We used ¾ in. diameter test-tubes containing 5% glycerine in 70% ethanol as pitfall traps, arranged in 4 x 2 trap grids with test-tubes 60 cm apart. Two trap grids were placed in burnt vegetation, two in small unburnt patches within the burnt area and two in unburnt vegetation adjacent to the burnt area and of equivalent vegetational composition. Test-tubes were placed in the ground on 16 March and emptied after

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1, 3, 4, 6, 7 and 8 days. Samples from all 16 test-tubes from each trapping area were grouped at each date and invertebrates were identified and counted.

We also searched systematically for invertebrates in the crowns of *Macrozamia riedlei* and *Xanthorrhoea preissii* plants which have been suggested as potential refuges (J. C. Taylor, pers. comm.). On 16 March, 10 plants of each species were selected in both burnt and unburnt areas. We searched deep in the crowns of both plants with trunks and plants with foliage at ground level. To assess the suitability of unburnt canopies as refuges, we collected arthropods from the canopies of 10 *Banksia* trees in both burnt and unburnt areas, beating and shaking branches over large plastic sheets.

Specimens of all species were lodged in the Zoology Department, University of Western Australia. Identifications of ants were made by Dr. J. D. Majer, Biology Department, Western Australian Institute of Technology, and species numbers refer to his collections. Identifications of spiders were made by Dr. B. Y. Main, Zoology Department, University of W.A., and all other identifications were made by comparisons with identified specimens at the Zoology Department or at the W.A. Department of Agriculture. Unidentifiable specimens were classified to family using keys in C.S.I.R.O. (1970).

RESULTS

Pitfall trap samples

The catches of arthropods varied from day to day in all three trapping areas (Table 1) probably reflecting daily variations in temperature and humidity. The arthropod fauna was richer and more abundant in both burnt trapping areas than in the unburnt area. Samples from trap grids in the burnt vegetation were very similar to those from the grids in small, unburnt patches (Table 2) and for the purpose of comparing particular species, we grouped these areas together. Of the 76 species trapped, only six were found exclusively in the unburnt area and all were represented by only a few individuals (Table 3). 27 species were common to both burnt and unburnt areas and almost all of these, except the nitidulid beetle and the Chironomid midge, are normally ground-dwelling or burrowing species (Table 4). 43 species appeared in burnt but not in unburnt areas and many of these are foliage inhabiting species including mantids, bugs and beetles (Table 5).

TABLE 1.—CUMULATIVE NUMBERS OF ARTHROPODS CAUGHT IN PITFALL TRAPS IN TWO BURNT AND ONE UNBURNT TRAPSITE. INCREMENT FROM PREVIOUS TRAP DAY SHOWN IN PARENTHESES.

Day	Burnt: Unburnt patch		Burnt: Burnt		Unburnt	
1	97		172		136	
3	594	(497)	638	(466)	345	(209)
4	748	(154)	836	(198)	411	(66)
6	905	(157)	1,043	(207)	499	(88)
7	1,070	(165)	1,233	(190)	535	(36)
8	1,240	(170)	1,446	(213)	620	(85)

TABLE 2.—NUMBERS OF INDIVIDUALS AND NUMBERS OF SPECIES OF ARTHROPODS REPRESENTED IN PITFALL TRAP SAMPLES FROM THREE TRAPSITES OVER EIGHT DAYS.

	Burnt: Unburnt patch	Burnt: Burnt	Unburnt
Numbers of Individuals	1,240	1,446	620
Numbers of species	49	52	33

TABLE 3.—SPECIES OF ARTHROPODS CAUGHT IN PITFALL TRAPS ONLY IN UNBURNT VEGETATION.

Species			Number of individuals
CLASS INSECTA			
Hymenoptera			
	Formicidae:	*Brachyponera* sp. (46)	1
Coleoptera			
	Staphilinidae		3
CLASS ARACHNIDA			
Phalangia (Opiliones)			1
Acarina		sp. 2	1
		Limnochares sp.	1
Aranaea			
	Salticidae		1

TABLE 4.—SPECIES OF ARTHROPODS CAUGHT IN PITFALL TRAPS IN BOTH BURNT AND UNBURNT VEGETATION.

Species				Numbers of individuals burnt		unburnt
				unburnt patch	burnt	
CLASS INSECTA						
Hymenoptera						
	Formicidae:	*Camponotus* sp.	(199)	480	794	147
			(110)	184	165	147
			(63)	10	36	11
		Meranoolus sp.	(157)	2	—	210
			(74)	1	—	1
			(96)	1	3	7
		Melophorus sp.	(227)	4	12	7
			(221)	1	2	3
		Stigmacros sp.	(396)	1	2	14
		Tapinoma sp.	(78)	4	13	4
		Chelaner sp.	(102)	—	4	3
		Xiphomyrmex sp	(36)	1	18	3
		Iridomyrmex sp.	(85)	89	175	17
			(375)	22	36	5
Orthoptera						
	Gryllidae: sp. 1			8	3	14
Coleoptera						
	Nitidulidae: sp. 3			2	2	2
	Unknown (larvae) sp. 1			—	1	1
Dermaptera						
	Labiduroidea sp. 1			—	1	1
Blattoidea						
	Blattidae: sp. 2			7	5	3
	sp. 4			1	—	1
Thysanoptera	sp. 1			—	1	1
Diptera						
	Chironomidae: sp. 1			—	1	1
CLASS COLEMBOLA						
Colembola						
	Entomobryidae:			6	2	7
CLASS ARACHNIDA						
Acarina		sp. 1		—	1	7
Aranaea						
	Lycosidae: *Lycosa serrata*			4	5	1
	Zodaridae: *Storena* sp.			1	6	1
	Gnaphosidae: sp. 1			2	2	1

TABLE 5.—SPECIES OF ARTHROPODS CAUGHT ONLY IN PITFALL TRAPS IN THE BURNT AREA, BOTH IN SMALL UNBURNT PATCHES AND BURNT VEGETATION.

Species				Numbers of individuals	
				Unburnt patch	Burnt
CLASS INSECTA					
Hymenoptera					
	Formicidae:	*Rhytidoponera* sp.	(31)	23	35
			(32)	—	28
		Iridomyrmex sp.	(217)	280	1
		Melophorus sp.	(A1233)	5	12
		Polyrachis sp.	(118)	32	16

	Crematogaster sp. (97)	38	—
	Stigmacros sp. (113)	—	2
	Xiphomyrmex sp. (36)	—	16
	Mutillidae: sp. 1	1	2
	sp. 2	—	1
	sp. 3	1	—
	Brachonidae: sp. 1	1	—
Isoptera			
	sp. 1	2	7
Mantoidea			
	Mantidae: sp. 1	1	—
Hemiptera			
	Cicadellidae	—	1
	Reduvioidea, Aradidae	—	5
	Reduviidae: sp. 1	1	1
	sp. 2	1	—
Coleoptera			
	Dermestidae	—	2
		—	1
	Curculionidae: sp. 1	1	—
	Carabidae	1	—
	Tenebrionidae	—	1
	Scarabaeidae	—	2
	Nitidulidae: sp. 1	3	—
	sp. 2	2	1
	Unknown sp. 2 (larva)	—	1
Thysanura			
	Lepismatidae	2	1
Blattoidea			
	Blattidae: sp. 1	1	—
	sp. 3	—	1
	Blaberidae	3	7
Diptera			
	Culicidae	—	4
CLASS MYRIAPODA			
Chilopoda			
	Scolopendridae: sp. 1	2	—
	sp 2	—	1
	Geophyllidae	1	—
CLASS CRUSTACEA			
Peracarida (Isopoda)			
	Oniscoidea	2	1
CLASS ARACHNIDA			
Acarina			
	sp. 3	1	—
Aranaea			
	Lycosidae: *Lycosa immensuata*	1	—
	Dictynidae: *Ixeuticus candidus*	1	2
	Clubionidae: *Miturga* sp.	1	2
	Dipluridae: *Aname*	—	1
	Ctenidae: *Elassoctenus harpax*	—	1
	sp. 2	1	—

Refuges

More species of arthropods were found in burnt than in unburnt *X. preissii* foliage and all animals in *M. riedlei* came from burnt plants (Table 6). Animals either used these refuges during the fire or congregated there in the two days between the fire and sampling. Several of the taxa trapped in burnt and not unburnt areas (see Table 5) were also found in the crowns of *M. riedlei* and *X. preissii* in the burnt area. These were the ants *Rhytidoponera* sp. 31, *Iridomyrmex* sp. 217 and *Polyrachis* sp. 118; the reduviid bug (sp. 1); the tenebrionid and nitidulid (sp. 1) beetles and the cockroach (Blattidae sp. 1).

TABLE 6.—SPECIES OF ARTHROPODS COLLECTED FROM TEN *MACROZAMIA RIEDLEI* AND TEN *XANTHORRHOEA PREISSII* CROWNS IN BURNT AND UNBURNT AREAS.

MACROZAMIA RIEDLEI	Burnt	Unburnt
CLASS INSECTA		
Hymenoptera: Formicidae: *Rhytidoponera* sp. (31)	X	
Iridomyrmex sp. (217)	X	
Coleoptera: Nitidulidae sp. 1	X	
Blattoidea: Blattidae sp. 1	X	
sp. 2	X	
CLASS ARACHNIDA		
Aranaea: Lycosidae, *Lycosa* sp. (immature)	X	
Total number of species	6	0

XANTHORRHOEA PREISSII	Burnt	Unburnt
CLASS INSECTA		
Hymenoptera: Formicidae: *Iridomyrmex* sp. (85)		X
Polyrachis sp. (118)	X	
Hemiptera: Reduviidae sp. 1	X	
Coleoptera: Tenebrionidae, *Adelium* sp	X	
Lycidae sp. 1	X	X
Chrysomelidae, *Paropsis* sp.		X
Blattoidea: Blattidae sp. 1	X	
sp. 2	X	X
CLASS MYRIAPODA		
Scolopendridae, *Cryptops* sp.	X	
CLASS ARACHNIDA		
Aranaea: Lycosidae, *Lycosa serrata?* (immature)	X	
Salticidae sp. 1	X	
Thomisidea sp. 1	X	
Theridiidae sp. 1	X	
Total number of species	11	4

Canopy samples

Banksia canopies in the burnt area yielded a much poorer fauna than those in the unburnt area (Table 7). Three of the species found in the unburnt canopies were also caught in pitfall traps in the burnt area (see Table 5).

TABLE 7.—SPECIES OF ARTHROPODS COLLECTED FROM TEN *BANKSIA* CANOPIES IN BURNT AND UNBURNT AREAS.

	Burnt	Unburnt
CLASS INSECTA		
Hymenoptera: Formicidae, *Polyrachis* sp. (118)		X
Mantoidea: Mantidae sp. 1		X
Coleoptera: Curculionidae sp. 1		X
sp. 2	X	
Coccinellidae, *Orcus* sp.		X
Lepidoptera: Lymantridae, *Orygia* sp. (larva)		X
CLASS ARACHNIDA		
Acarina sp. 2		X
Aranaea: Sparassidae, *Delena cancerides*		X
Total number of species	1	7

DISCUSSION

The most interesting feature of this study is the abundance and diversity of arthropod species caught in pitfall traps following fire. Close examination of the natural histories of individual species and a knowledge of where they may be found in unburnt vegetation would allow a good interpretation of these data but this sort of information is lacking for most species of Australian invertebrates. The data we have presented suggest the following explanation. Many arthropods survive fire by various means: burrowing, flying ahead of the flames or finding refuges, and most of these species will be the normal inhabitants of the foliage and stems of shrubs and trees. Those animals which survive will subsequently be restricted to moving at ground level where they may then be caught using the pitfall trap technique. Increases in numbers of ground-dwelling species such as ants appearing in traps may reflect increased feeding activity and foraging distances. We consider that these results reflect the physical changes caused by fire, such as the removal of small stems and foliage, and would be similar after mechanical clearing of all above-ground vegetation by slashing or mowing. These disturbances can be seen as a simplification of the habitat from three to two dimensions.

Both *M. riedlei* and *X. preissii*, which are common at the Marsupial Breeding Station, provided refuges for several arthropod groups. Although this has been observed before, this study distinguished between species normally found in these plants in the absence of fire and species which use them only as a refuge. Other refuges common in areas which receive a cool, patchy burn are fallen logs (Main, 1978; Majer, pers. comm.). The numbers of individuals which escape fire in refuges, and their subsequent survival, are important in determining whether they may reinvade the regenerating vegetation. For several months after the fire we observed a greatly increased frequency of feeding by insectivorous birds. Species such as the Scarlet Robin *(Petroica multicolor)*, Grey Fantail *(Riphidura fuliginosa)*, Rufous Whistler *(Pachycephala rufiventris)*, Western Shrike-thrush *(Colluricincla rufiventris)* and Magpie *(Gymnorhina dorsalis)* were commonly seen feeding on the ground and possibly caused high mortalities among the formerly arboreal arthropods, particularly as many species, cryptically coloured and shaped in foliage, are conspicuous on the burnt, black background. The predatory, burrowing arthropods such as spiders and ants may also cause some mortality among the group of displaced species.

Starvation may also lead to the extinction of displaced arthropod populations after fire, although regrowth from rhizomes of monocotyledons and lignotubers of shrubs is very rapid. The invertebrates which survive fire will lack plant material both as food and as protection from predators for several weeks. Predatory arthropods may show a pattern of post-fire abundance followed by a population crash as prey populations increase dramatically and then disappear. Groups such as spiders, however, can withstand long periods without feeding (B. Y. Main, pers. comm.) and growth rates of wolf spiders (Lycosidae), which can be easily measured, would reflect changes in ground arthropod populations. Long term, quantitative studies are required to determine these sorts of population changes after fire and one particularly important feature of the post-fire situation is the suitability of small, unburnt patches of vegetation in burnt areas as reservoirs of invertebrates from which they can invade the regenerating vegetation.

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A BIRD CENSUS OF GARDEN ISLAND, W.A.

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INTRODUCTION

Following the establishment of HMAS *Stirling* on Garden Island, W.A. (32°15'S, 115°41'E), the Australian Department of Defence has taken an active interest in the environmental management of the island. An expression of this interest was the approval given by the Commodore of HMAS *Stirling* for a party from the Western Australian Group of the RAOU to visit the island during the weekend March 17/18, 1979 and survey it as part of the *Atlas of Australian Birds.* So that the data collected could be compared with that obtained by other parties on subsequent visits, a point count census was conducted.

METHODS

Census methods have been well reviewed by Robbins (1978) who indicates that in the northern hemisphere the Indices Ponctuals d'Abondance, IPA, method is acceptable for forest birds in the breeding season but not so good in the non-breeding season because so many birds form nomadic or migratory flocks, greatly increasing the variability of a series of observations. In Western Australia, however, many species hold territories throughout the year and for these species the IPA method can probably be applied, with qualifications, throughout the year. Robbins (1978) indicates that at least two counts are needed. In the present series of observations it was not practical to make two counts at the same place and time on different days, nor, of course, could methods of assessment appropriate to the breeding season be adopted. Some modification of the methods advocated by Ferry and Frochot (1970), therefore, had to be made.

The vegetation of Garden Island has been described by McArthur (1957) and recently McArthur and Bartle (1978) have published a vegetation map of the area. The vegetation is largely unchanged by European settlement and is dominated by *Callitris preissii, Acacia rostellifera* and *Melaleuca lanceolata.* The structure of the vegetation is unlike that of the mainland because it usually has only a single layer, shrub and herb layers being very poorly represented in stands of the dominant trees. The island has been isolated from the mainland for at least 4,000 years and perhaps for as long as 100,000 years (McArthur, 1957). Abbott (1980) published a general account of the birds of Garden Island based on several recent visits and reviewed earlier literature.

Garden Island was visited for a day in August, 1978 and a general appreciation of its layout and bird life obtained. On March 17, 1979, seven sites were selected covering the five main vegetation associations on the island.

Table 1 gives the vegetation type sampled at each site, following the description of McArthur and Bartle (1978). The Australian Map Grid reference for the first of each quadrats at each site is also given, because this grid is printed on McArthur and Bartle's map. At each site six quad-